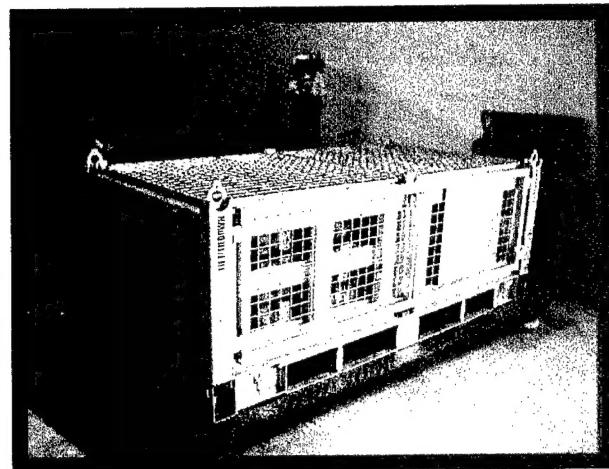


**FINAL REPORT  
OCTOBER 2002**

**REPORT NO. 02-30**



**VEHICLE STORAGE AND TRANSPORT FRAME (VSTF),  
ENGINEERING EVALUATION TESTS :  
MIL-STD-1660, "DESIGN CRITERIA FOR AMMUNITION UNIT LOADS"  
TP-94-01, "TRANSPORTABILITY TESTING PROCEDURES"**

Prepared for:

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U.S. Army Defense Ammunition Center  
ATTN: SOSAC-DET  
1 C Tree Road  
McAlester, OK 74501-5900



**VALIDATION ENGINEERING DIVISION  
MCALESTER, OKLAHOMA 74501-9053**

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**REPORT NO. 02-30**

**OCTOBER 2002**

**VEHICLE STORAGE AND TRANSPORT FRAME**

**EVALUATION TESTS:**

**MIL-STD-1660, ENGINEERING, "DESIGN CRITERIA  
FOR AMMUNITION UNIT LOADS"**

**TP-94-01, "TRANSPORTABILITY TESTING PROCEDURES"**

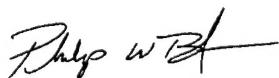
**ABSTRACT**

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SOSAC-DEV) was tasked by the Transportation Engineering Division (SOSAC-DET) to conduct an Engineering Evaluation Test to determine if the Vehicle Storage and Transport Frame (VSTF), manufactured by Mobile Shelter Systems, could be utilized for the unitization and transportation of metal ammunition cans and boxed ammunition. The testing was conducted for informational purposes only. The VSTF was evaluated by the testing procedures set forth in MIL-STD-1660 and TP-94-01. Stacking, vibration, drop, incline impact, sling compatibility, forklift handling, disassembly and on/off road transportability testing were conducted on the VSTF.

The testing caused severe damage to the VSTF. During testing, the outside tabs on the top shelves failed. Welds failed on both the cross members and the base corners, and the reinforced tabs on the top shelves were bent during testing. The failures created an unsafe condition which would preclude the continued safe transport of ammunition.

As tested, the VSTF, manufactured by Mobile Shelter Systems, did not successfully complete the MIL-STD-1660 and TP-94-01 test requirements.

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REPORT NO. 02-30

**VEHICLE STORAGE AND TRANSPORT FRAME (VSTF)  
ENGINEERING EVALUATION TESTS  
MIL-STD-1660, "DESIGN CRITERIA FOR UNIT LOADS"  
TP-94-01, "TRANSPORTABILITY TESTING PROCEDURES"**

TABLE OF CONTENTS

PART	PAGE NO.
1. INTRODUCTION .....	1-1
A. BACKGROUND .....	1-1
B. AUTHORITY .....	1-1
C. OBJECTIVE .....	1-1
D. CONCLUSION .....	1-1
2. ATTENDEES .....	2-1
3. TEST PROCEDURES .....	3-1
4. TEST EQUIPMENT .....	4-1
5. TEST RESULTS .....	5-1
6. DRAWINGS.....	6-1

## **PART 1 – INTRODUCTION**

**A. BACKGROUND**. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SOSAC-DEV), conducted an Engineering Evaluation Test to determine if the Vehicle Storage and Transport Frame (VSTF), manufactured by Mobile Shelter Systems, could be utilized for the unitization and transportation of metal ammunition containers and wooden boxed ammunition. The testing was conducted for informational purposes only. The VSTF was evaluated by the testing procedures set forth in MIL-STD-1660, "Design Criteria for Ammunition Unit Loads" and TP-94-01, "Transportability Testing Procedures." Stacking, vibration, drop, incline impact, sling compatibility, forklift handling, disassembly and on/off road transportability testing were conducted on the VSTF. The unitization (container loading) procedures were provided by the DAC, Transportation Engineering Division (SOSAC-DET) (See Part 6).

**B. AUTHORITY**. This test was conducted IAW mission responsibilities delegated by the U.S. Army Operations Support Command, Rock Island, IL. Reference is made to the following:

1. AR 740-1, 15 June 2001, Storage and Supply Activity Operation
2. IOC-R, 10-23, Mission and Major Functions of USADAC, 7 January 1998.

**C. OBJECTIVE**. The objective of the testing was to determine if the VSTF could be used as a pallet container and could successfully pass the MIL-STD-1660 and TP-94-01 test requirements. The testing was conducted for informational purposes only.

**D. CONCLUSION**. The testing caused severe damage to the VSTF. During testing, the outside tabs on the top shelves failed. Welds failed on both the cross members and the base corners, and the reinforced tabs on the top shelves were

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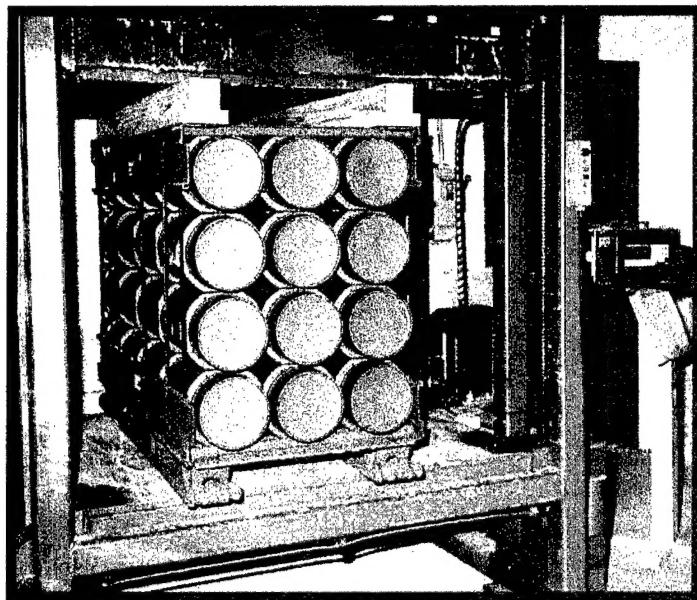
Mobile Shelter Systems AS  
Industrigata 3  
N-3160 Stokke, Norway

## PART 3 - TEST PROCEDURES

The test procedures outlined in this section were extracted from the MIL-STD-1660 and TP-94-01. The tests are conducted on ammunition pallet units or unit loads and are summarized as follows:

### **A. MIL-STD-1660:**

**1. STACKING TEST.** The specimen will be tested to simulate a stack of identical items stacked 16 feet high, for a period of one hour. This stacking load will be simulated by subjecting the specimen to a compression weight equal to an equivalent 16-foot stacking height. Photo 1 below shows an example of a unit load in the compression tester.

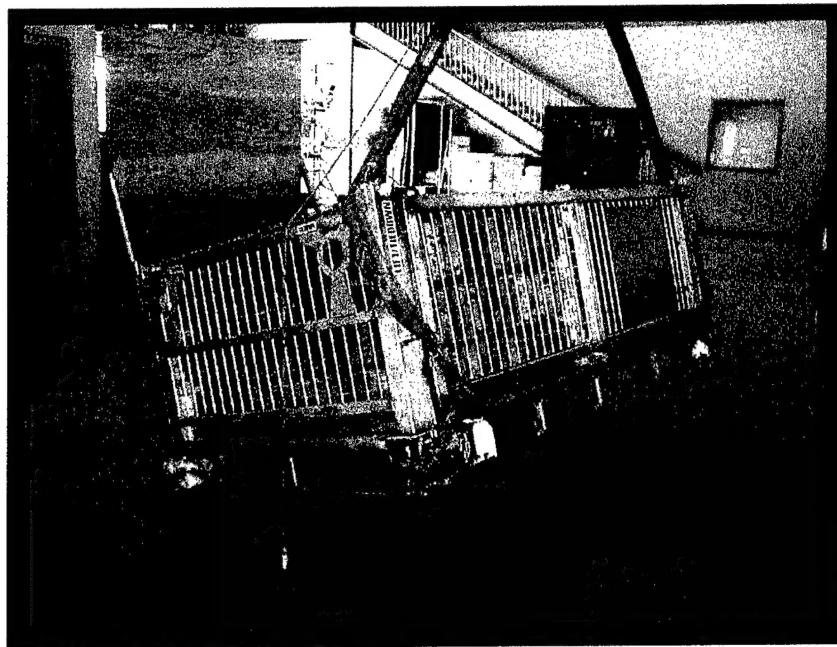


**Photo 1. Example of Compression Tester.  
(2.75-inch Hydra 70, PA151 Rocket Pallet in the compression tester.)**

should not be high enough to cause the specimen to slide on the supports when the dropped end is raised for the drop. The unsupported end of the specimen is then raised and allowed to fall freely to the concrete, pavement, or similar unyielding surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection will conform to the following tabulation:

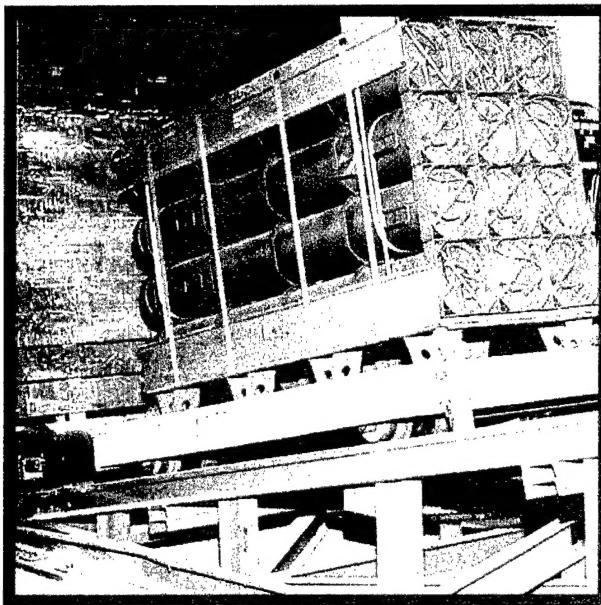
GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
150-250	60-66	36	27
250-400	66-72	32	24
400-600	72-80	28	21
600-1,000	80-95	24	18
1,000-1,500	95-114	20	16
1,500-2,000	114-144	17	14
2,000-3,000	Above 145- No limited	15	12
Above – 3,000		12	9

Figure 1



**Photo 3. Example of Edgewise Rotational Drop Test  
(Vehicle Storage and Transport Frame)**

**4. INCLINE-IMPACT TEST.** This test is conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen will be placed on the carriage with the surface or edge to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage will be brought to a predetermined position on the incline and released. If it were desired to concentrate the impact on any particular position on the container, a 4- x 4-inch timber may be attached to the bumper in the desired position before the test. The carriage will not strike any part of the timber. The position of the specimen on the carriage and the sequence in which surfaces and edges are subjected to impacts may be at the option of the testing activity and dependent upon the objective of the test. When the test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen will be subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at the time of the impact will be 7 feet-per-second. Photo 4 shows an example of this test.



**Photo 4. Example of the Incline-Impact Test.  
(2.75-Inch, Hydra 70, PA151 Rocket Pallet on incline-impact tester.)**

**5. SLING COMPATIBILITY TEST.** The specimen utilizing special design or non-standard pallets will be lifted, swung, lowered and otherwise handled as necessary, using slings of the types normally used for handling the unit loads under consideration. Slings will be easily attached and removed. Danger of slippage or disengagement when load is suspended will be cause for rejection of the specimen.

**6. FORKLIFTING TESTS.** The specimen will be lifted clear of the ground by a forklift from the end of the specimen and transported on the forks in the level or back-tilt position across a hard pavement for a distance of not less than 100 feet. The forklift will also pass over the forklift hazard course as outlined in MIL-STD-1660. The hazard course will consist of parallel pairs of 1-inch boards spaced 54 inches apart and will be laid flat wise on the pavement across the path of the forklift. The first pair will be placed securely across the forklift's path and centered 30 feet from the starting point; the second pair will be laid 60 feet from the starting point at an angle of approximately 60 degrees to the path so the first

wheel strikes first; and the third pair will be laid 90 feet from the starting point approximately 75 degrees to the path so the right wheel strikes first. The forklift will pass over the forklift hazard course 3 times in approximately 23 seconds, and then be brought to a stop. The load shall be observed for deflection and damage. The specimen will be rotated 90 degrees and the load lifted from the side and the above steps repeated.

**7. DISASSEMBLY TEST.** Following all rough handling tests the specimen may be squared up within 2 inches of its original shape and on a flat level surface. The strapping will then be cut and removed from the palletized load. Assembly of the specimen will be such that it retains its unity upon removal of the strapping.

## B. TRANSPORTABILITY TEST. ON/OFF ROAD TESTS.

1. HAZARD COURSE. The test load or vehicle will be transported over the 200-foot-long segment of concrete-paved road consisting of two series of railroad ties projecting 6 inches above the level of the road surface. The hazard course will be traversed two times (see Figure 2).

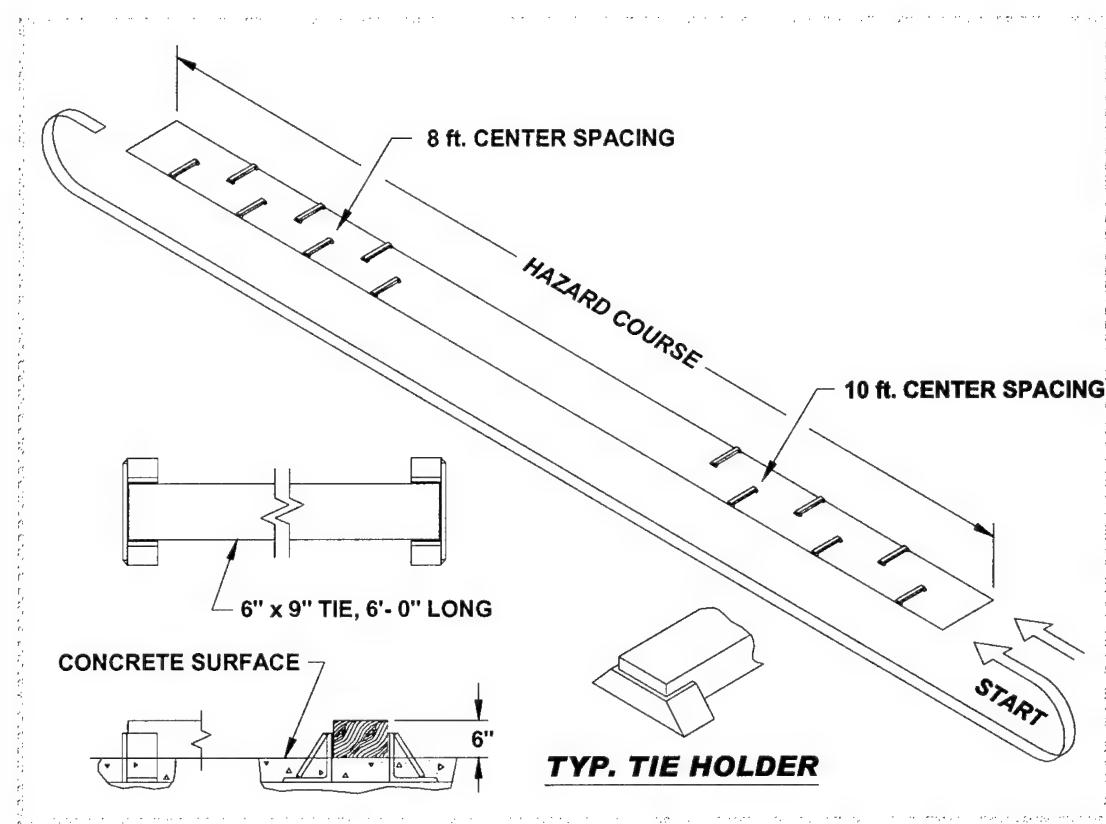


Figure 2. Hazard Course Sketch

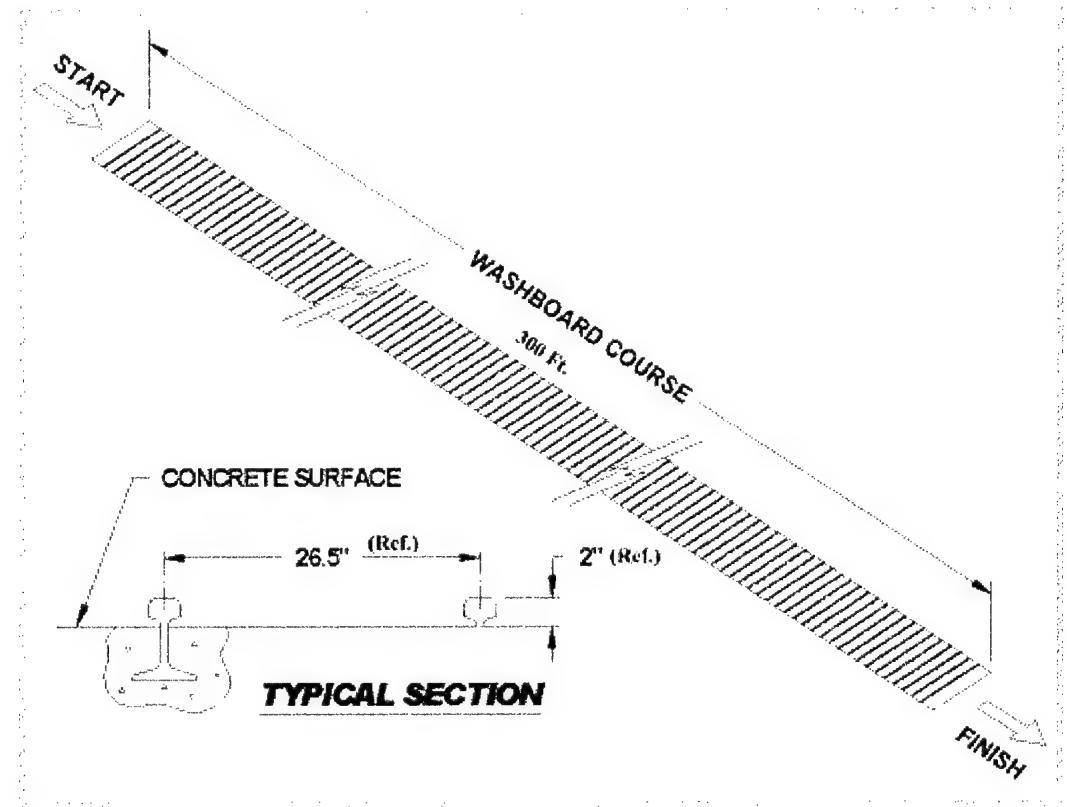
- a. The first series of ties are spaced on 10-foot centers and alternately positioned on opposite sides of the road centerline for a distance of 50 feet.
- b. Following the first series of ties, a paved roadway of 75 feet separates the first and second series of railroad ties.
- c. The second series of ties are spaced on 8-foot centers and alternately positioned on opposite sides of the road centerline for a distance of 50 feet.
- d. The test load is driven across the hazard course at speeds that will

produce the most violent vertical and side-to-side rolling reaction obtainable in traversing the hazard course (approximately 5 mph).

**2. ROAD TRIP.** The test load or vehicle will be transported for a distance of 30 miles over a combination of roads surfaced with gravel, concrete, and asphalt. The test route will include curves, corners, railroad crossings and stops and starts. The test load or vehicle will travel at the maximum speed for the particular road being traversed, except as limited by legal restrictions.

**3. PANIC STOPS.** During the road trip, the test load or vehicle will be subjected to three (3) full airbrake stops while traveling in the forward direction and one in the reverse direction while traveling down a 7 percent grade. The first three stops are at 5, 10, and 15 mph while the stop in the reverse direction is approximately 5 mph. This testing will not be required if the Rail Impact Test is performed.

**4. WASHBOARD COURSE.** The test load or vehicle will be driven over the washboard course at a speed that produces the most violent response in the vertical direction.



**Figure 3. Washboard Course Sketch**

## PART 4 - TEST EQUIPMENT

### **A. COMPRESSION TESTER.**

1. Manufacturer:	Ormond Manufacturing
2. Platform:	60- x 60-inches
3. Compression Limit:	50,000 pounds
4. Tension Limit:	50,000 pounds

### **B. TRANSPORTATION SIMULATOR.**

1. Manufacturer:	Gaynes Laboratory
2. Capacity:	6,000-pound payload
3. Displacement:	1/2-inch amplitude
4. Speed:	50 to 400 RPM
5. Platform:	5- x 8-foot

### **C. INCLINED PLANE.**

1. Manufacturer:	Conbur Incline
2. Type:	Impact Tester
3. Grade:	10 percent incline
4. Length:	12-foot

### **D. TRUCK UTILITY: CARGO/TROOP CARRIER, 1.25 TON, 4X4**

High Mobility Multipurpose Wheeled Vehicle (HMMWV)

Model: M998

Manufacturer: A.M. General Corporation

Mfg Serial Number: 011784

Registration Number: NG256K

Date of Delivery: 03/86

## **PART 5 - TEST RESULTS**

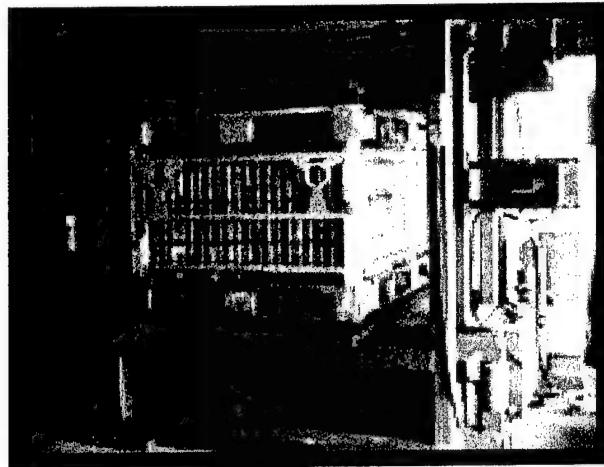
**A. PALLET DATA**. Each VSTF was inertly loaded to the specified design weight using inert simulated ammunition in M2A1 metal boxes. Special care was taken to ensure that each M2A1 metal box had the proper amount of weight in order to achieve a realistic unit center of gravity (CG). Once properly prepared, the VSTFs were tested using MIL-STD-1660 and TP-94-01 requirements.

### **VEHICLE STORAGE AND TRANSPORT FRAME (VSTF)**

Test Date:	10-18 September 2002
Gross Weight:	2,335 pounds without dunnage
	2,395 pounds with dunnage
Length:	82 inches
Width:	45.25 inches
Height:	33 inches
Mfg:	Mobile Shelter Systems

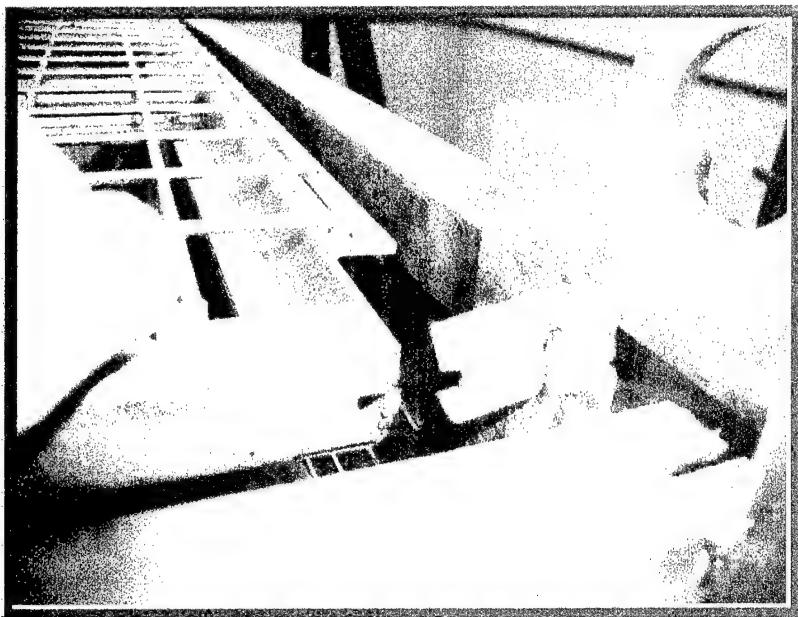
### **B. MIL-STD-1660:**

**1. COMPRESSION TEST**. The test specimen was compressed with a load force of 11,750 pounds for 60 minutes on 10 September 2002. No damage was noted as a result of this test. See Photo 5 of the test specimen in the compression unit.

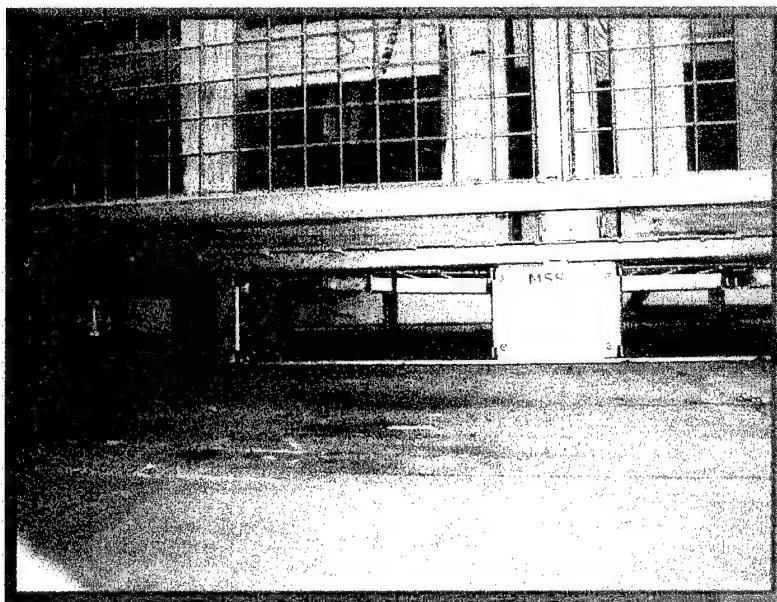


**Photo 5. VSTF in the Compression Tester.**

2. **REPETITIVE SHOCK TEST.** The specimen was vibrated 90 minutes at 234 RPM in the longitudinal orientation. During testing the outside tabs on the top shelves failed. The payload could be accessed without disassembly of the VSTF. Photo 6 shows one of the damaged tabs. Testing was suspended due to the tab failure. A second VSTF was assembled and wooden dunnage was added to the load. Also, reinforcement was added to the tabs of the top shelves. The specimen was vibrated 90 minutes at 220 RPM in the lateral orientation and at 200 RPM in the longitudinal direction. Testing was stopped prior to completion of the testing in the longitudinal direction due to damage to the VSTF cross members. Photo 7 shows the damaged cross members. The cross member welds failed due to forces incurred during testing.



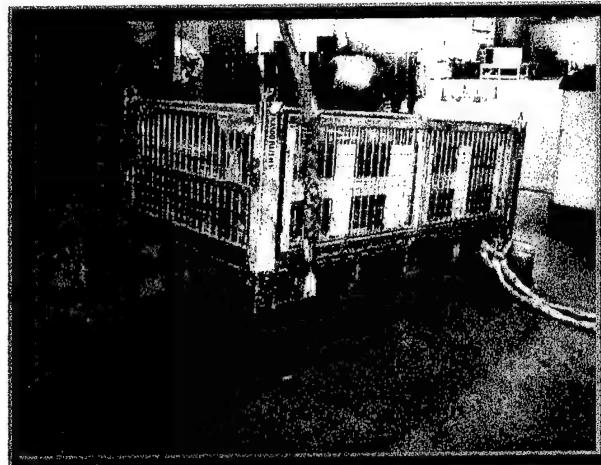
**Photo 6. Damaged Top Shelf Tabs of the VSTF From Repetitive Shock Testing.**



**Photo 7. Damaged VSTF Cross members.**

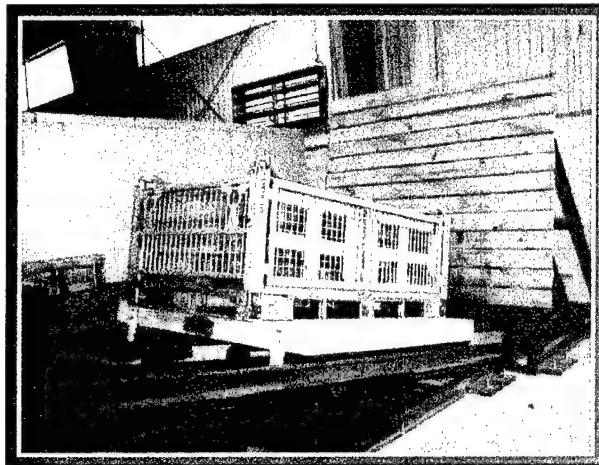
**3. EDGEWISE ROTATIONAL DROP TEST.** In order to identify further potential weaknesses, it was decided to continue the testing sequence on a third VSTF which was constructed using the base assembly from the first VSTF and the side panels and top shelves from the second VSTF tested. Testing was then resumed. The specimen was edgewise rotationally dropped from a height of 15

inches on both longitudinal sides and both lateral sides. Photo 8 shows the VSTF during the lateral side drop test. Welds at opposite corners and the three center cross members were broken during testing. Since the VSTF retained adequate integrity and was still considered safe to handle, testing was continued.

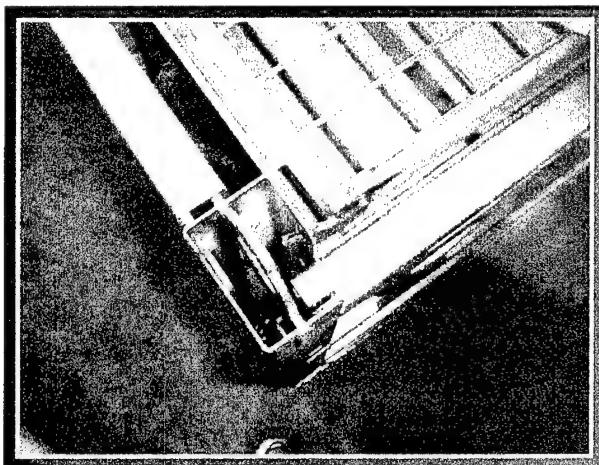


**Photo 8. Drop Test on the Lateral Sides of the VSTF.**

**4. INCLINE-IMPACT TEST.** The VSTF was impact tested on both longitudinal sides and both lateral sides. See Photo 9 for the VSTF during the lateral incline-impact test. Final inspection upon completion of testing revealed that the VSTF had numerous cracked welds on the base frame, bowing in the sides and the tabs in the top shelves bent. Photo 10 shows the bent top shelf tabs of the VSTF. Testing was continued since the VSTF retained adequate integrity and was still considered safe to handle.



**Photo 9. Incline-Impact Testing of the VSTF**

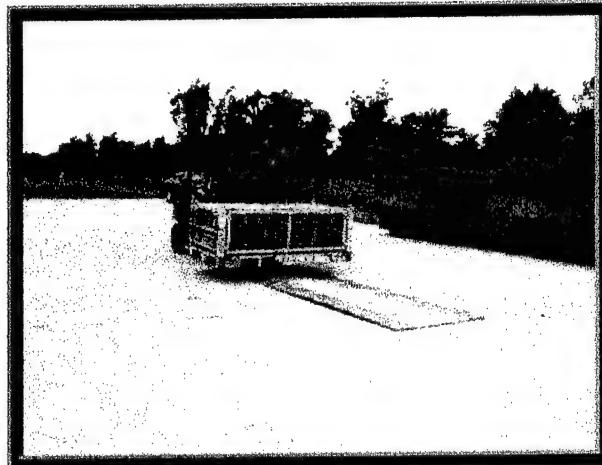


**Photo 10. Bent Tabs of VSTF**

**5. SLING COMPATIBILITY TEST.** During testing the VSTF was lifted, swung, lowered and handled as necessary using slings of the types normally used for handling the unit loads. The slings were easily attached and removed.

**6. FORKLIFTING TEST.** The VSTF was lifted clear of the ground by a forklift from both longitudinal sides and both lateral sides and transported on the forks. Photo 11 shows the VSTF during the Forklift Test. No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle.

**7. DISASSEMBLY TEST.** During the disassembly of the VSTF no additional damage was discovered. The VSTF retained adequate integrity and was still considered safe to handle. The disassembly test was conducted following the completion of the Transportability Testing.



**Photo 11. VSTF during the Forklifting Test**

**C. TRANSPORTABILITY TESTING. (ON/OFF ROAD TESTS).**

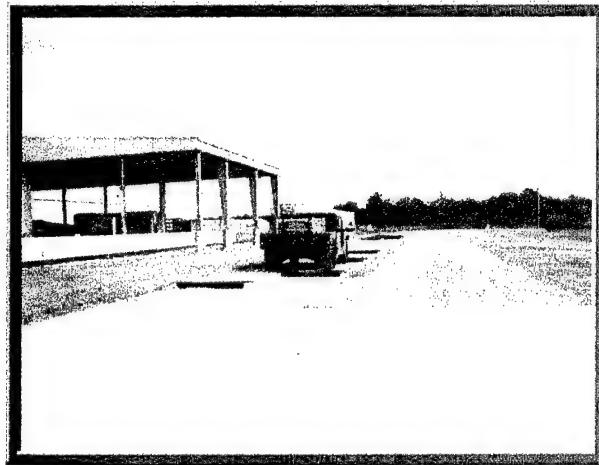
**1. HAZARD COURSE.**

Pass No.	Elapsed Time	Avg. Velocity (MPH)
1	27 Seconds	4.7
2	24 Seconds	5.3

**Figure 4.**

**Remarks:**

- a. Figure 4 lists the average speeds of the test load through the Hazard Course Passes 1 and 2.
- b. No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle. Photo 12 shows the VSTF during transport over the Hazard Course.



**Photo 12. VSTF during Hazard Course Transport**

b. **ROAD TRIP:** No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle.

c. **PANIC STOPS:** No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle.

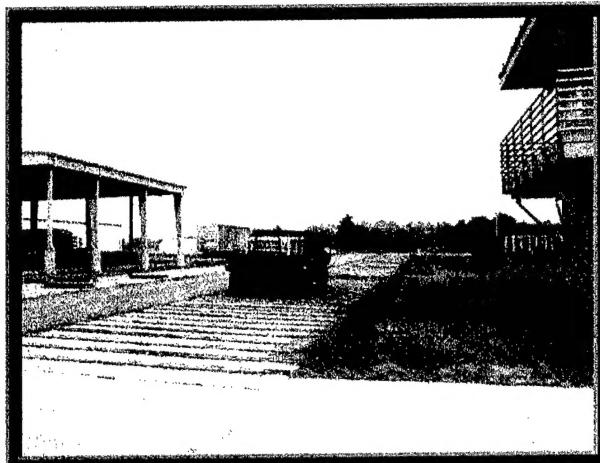
d. **HAZARD COURSE:**

Pass No.	Elapsed Time	Avg. Velocity (MPH)
3	23 Seconds	5.6
4	20 Seconds	6.4

**Remarks:**

- a. Figure 5 lists the average speeds of the test load through the Hazard Course Passes 3 and 4.
- b. No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle.

e. **WASHBOARD**: No additional damage occurred and the testing was continued since the VSTF retained adequate integrity and was still considered safe to handle. Photo 13 shows the VSTF during transport over the washboard course.



**Photo 13. VSTF during Washboard Testing**

**D. CONCLUSION.** As tested, the VSTF, manufactured by Mobile Shelter Systems, did not successfully complete MIL-STD-1660 and TP-94-01 testing requirements, due to previously noted structural damage.

## **PART 6 – DRAWINGS**

The following drawing represents the load configuration that was subjected to the test criteria.

# **MIL-STD-1660 TESTING OF THE VEHICLE - TRANSPORT STORAGE FRAME (V-STF) LOAD SKETCH**

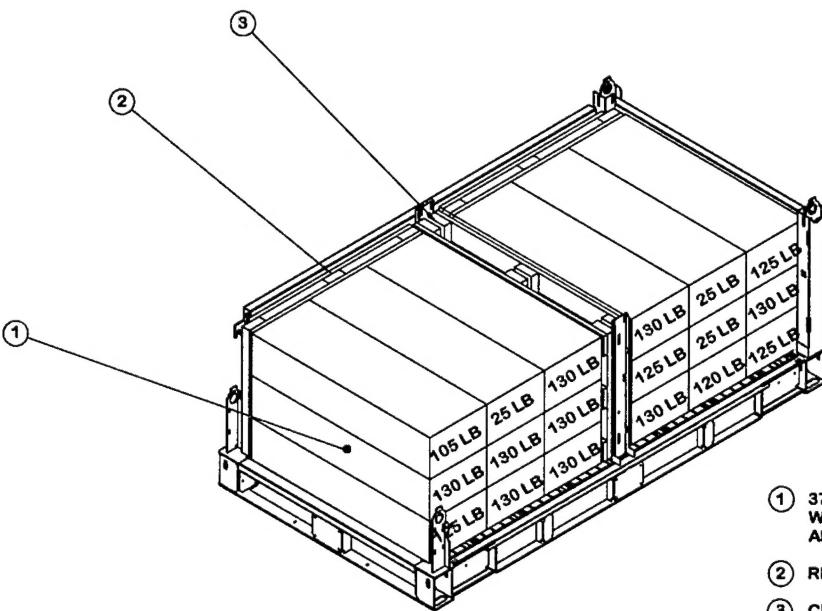
## **TEST #2**

**THIS TWO PAGE DOCUMENT DEPICTS PROCEDURES FOR UNITIZING  
THE TEST LOAD FROM THE V-STF MIL-STD 1660 TESTING.**

**OVERALL DIMENSIONS OF THE V-STF:  
81-3/4" L X 45-1/8" W X 33-1/16" H**

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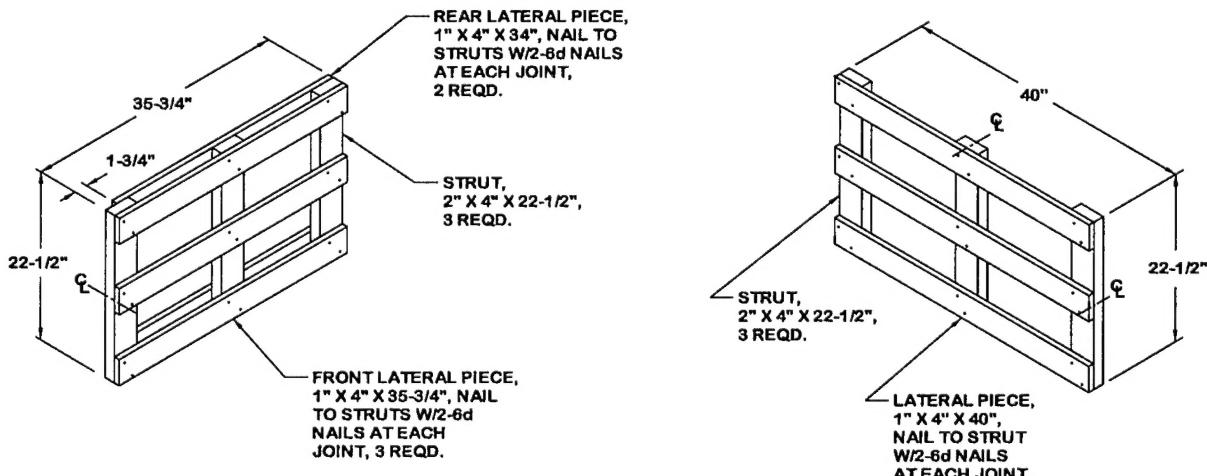
#### NUMBERED ITEMS

- ① 37-1/4" L X 12" W X 7-1/2" H, 105MM WOOD BOXES, WEIGHTED AS SHOWN ABOVE, LOADED AS SHOWN ABOVE, 18 REQUIRED.
- ② REAR ASSEMBLY, SEE DETAIL BELOW, 2 REQUIRED.
- ③ CENTER ASSEMBLY, SEE DETAIL BELOW, 2 REQUIRED.

#### V-STF UNIT LOAD

18 BOXES OF 105MM HOWITZER AT (VARY)	-----	1,970 LBS (APPROX)
DUNNAGE	-----	55 LBS (APPROX)
V-STF	-----	370 LBS
 TOTAL WEIGHT		-----
CUBE		-----
		2,395 LBS (APPROX)
		70.6 CU FT (APPROX)

BILL OF MATERIAL		
LUMBER	LINEAR FEET	BOARD FEET
1" X 4"	49.2	16.4
2" X 4"	22.5	15
NAILS	NO. REQD	POUNDS
6d (2")	48	.29



#### REAR ASSEMBLY DETAIL

2 REQD

#### CENTER ASSEMBLY DETAIL

2 REQD